REMARKS

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, claim 1, and various of the other previously considered independent claims, have been amended to recite that in burying the buried insulation film into the oxidized trench, the insulating film also is formed on the oxidation prevention film; the independent claims have also been amended to recite that after burying the buried insulating film, the insulating film from the oxidation prevention film is removed; and after this removal of the insulating film from the oxidation prevention film, the recited upper end portion of the trench is oxidized. Note, for example, page 14, lines 4-12 of Applicants' Specification.

In light of amendments to the independent claims as described in the foregoing, claims 14 and 40 have been cancelled without prejudice or disclaimer; and, moreover, claims 42, 44 and 48 have been amended to delete recitation that the step of removing the buried insulating film formed on the oxidation prevention film is performed before the step of oxidizing the semiconductor substrate at the upper end portion of the trench.

Initially, Applicants respectively request reconsideration and withdrawal of the finality of the Office Action mailed July 30, 2002. In this regard, note that the Examiner has objected to the Amendment filed December 28, 2001, as introducing new matter into the disclosure, and has rejected, inter alia, claim 9, under the first paragraph of 35 USC 112, the Examiner contending that, inter alia, the recitation "selectively oxidizing" is not supported by the original disclosure. However, attention is respectfully directed to claim 9 as added by the Preliminary Amendment filed March 17, 1999, in the above-identified application, having the step (e) of performing

a second oxidation to selectively oxidize an opening side of the completely filled trench regions in the substrate. This recitation in claim 9 has been continued to the Amendment filed December 28, 2001; note claim 9 (Thrice Amended) on pages 6 and 7 of the Amendment filed December 28, 2001. Accordingly, it is respectfully submitted that the Examiner has raised a new issue in the Office Action mailed July 30, 2002, (that is, support in the original disclosure for "selective oxidation") in connection with a recitation previously in the above-identified application (that is, has raised a new issue not necessitated by Applicants' amendments to their claims in the Amendment filed December 28, 2001). In view thereof, it is respectfully submitted that the Examiner cannot properly make the Office Action mailed July 30, 2002, a Final rejection. See Manual of Patent Examining Procedure 706.07(a).

Additionally, note that the Examiner has submitted additional evidence in the Office Action mailed July 30, 2002, for the prior art rejections using the article by Lee, et al. as prior art (that is, the Abstract of the article by Lee, et al.) The additional evidence was provided by the Examiner for establishing that Lee, et al. constitutes prior art. As previously argued by Applicants, the Examiner had not previously established that the article by Lee, et al. was prior art, since the Examiner had provided no evidence as to the date of publication of Lee, et al. It is also respectfully submitted that in view of this new evidence submitted by the Examiner for establishing the Lee, et al. article as prior art, the Examiner cannot properly make the Office Action mailed July 30, 2002, a Final rejection. Thus, for either of the two reasons set forth in the foregoing (that is, the new issues raised by the Examiner under 35 USC 132 and/or the first paragraph of 35 USC 112, and the

prior art date of Lee, et al. (raised under 35 USC 103), reconsideration and withdrawal of the finality of the Office Action mailed July 30, 2002, are respectfully requested.

The contention by the Examiner in Item 13 on page 1 of the office Action mailed July 30, 2002, that Applicants' Amendment filed May 10, 2002, necessitated the new ground of rejection of, inter alia, claim 9, is respectfully traversed, since claim 9 previously included selective oxidation.

In any event, entry of the present amendments is respectfully requested, notwithstanding finality of the Office Action mailed July 30, 2002. In this regard, noting claims as previously considered by the Examiner, including claims 5, 42, 44, 45, 47 and 48, it is respectfully submitted that the present amendments do not raise any new issues, including any issue of new matter. Furthermore, by providing consistent recitations in, for example, all independent claims, it is respectfully submitted that the present Amendment materially limits issues remaining in connection with the above-identified application; and, at the very least, presents the claims in better form for appeal. Furthermore, noting additional arguments and rejections, and additional evidence, in the Office Action mailed July 30, 2002, as well as additional objections raised by the Examiner in the Office Action mailed July 30, 2002, it is respectfully submitted that the present amendments are clearly timely.

In view of all of the foregoing, and even assuming, arguendo, that the finality of the Office Action mailed July 30, 2002, is proper, Applicants have made the necessary showing under 37 CFR 1.116(c), such that entry of the present amendments is clearly timely.

Applicants respectfully traverse the objection to their Amendment filed December 28, 2001, as introducing new matter into the disclosure, as alleged by the Examiner in Item 2 on page 2 of the Office Action mailed July 30, 2002. As shown in the following, it is respectfully submitted that Applicants have <u>clear</u> support and description, as required under the first paragraph of 35 USC 112, for the phrases objected to by the Examiner in the first paragraph of Item 2 on page 2 of the Office Action mailed July 30, 2002.

In this regard, the Examiner's attention is respectfully directed to pages 14 and 15 of Applicants' original Specification. Note, in particular, the sole full paragraph on page 14, the paragraph bridging pages 14 and 15, and the first full paragraph on page 15, of Applicants' Specification. Note that the description therein sets forth that an additional oxidation is performed after the buried insulating film 9 has been etched back (note Fig. 2I); that, in this case, since the buried insulating film 9 has already been formed inside the trench, oxidation proceeds from near the trench upper end portion and the inside of the trench is hardly oxidized; and that only portions in the proximity of the trench upper end portion 12 are oxidized preferentially and the formation of the radius of curvature of the trench upper end portion 12 is promoted. Note also the further description in the first paragraph on page 15 of Applicants' Specification, that after this additional oxidation is completed, the formation step of the device isolation oxide film is completed by removing the polycrystalline silicon thin film 18 and the pad oxide film 2. It is respectfully submitted that this description in Applicants' Specification, disclosing that only the portions in the proximity of the trench upper end portion are oxidized preferentially,

and that oxidation hardly proceeds substantially near the bottom of the trench, provides clear support for the expressions objected to by the Examiner.

On page 20 of the Amendment filed December 28, 2001, Applicants specifically referred to the sole full paragraph on page 14, the paragraph bridging pages 14 and 15, and also referred to pages 23-25 of their Specification, with respect to support for the subject matter of, inter alia, claims 45-47. Pages 23-25 contain disclosure corresponding to that previously referred to in connection with pages 14 and 15 of Applicants' Specification. In particular, note that on page 23, lines 20-24, there is disclosure that since the buried insulating film 9 has already been formed inside the trench of the silicon substrate, oxidation proceeds from portions near the trench upper end portion 12 and the inside of the trench is hardly oxidized. Clearly, Applicants provide support for recitations in the present claims, in connection with oxidation of the upper end portion of the trench, with substantially no oxidation of other portions of the trench; or the selective oxidation, as in the present claims.

The above-referred-to portions of Applicants' Specification refer to preferential oxidation or oxidation substantially of only the upper end portion of the trench. It is respectfully submitted that this description clearly supports recitation of selective oxidation, under the requirements of the first paragraph of 35 USC 112. In this regard, it is respectfully submitted that Applicants need not use the express terms, in their Specification, in the claims, in order to satisfy the requirements of the first paragraph of 35 USC 112.

In view of the foregoing, reconsideration and withdrawal of the objection to the Amendment filed December 28, 2001, is respectfully requested. In this regard, the

requirement by the Examiner to cancel "the new matter" is respectfully traversed. As seen in the foregoing, the phrases objected to by the Examiner are not new matter; accordingly, it is respectfully submitted that there are no recitations, constituting new matter, that must be cancelled from the present claims.

The rejection of claims 1-6, 9-15 and 17-48 under the first paragraph of 35 USC 112, on the basis that there does not appear to be a written description of the claim limitation "selective oxidation" in the application as filed, is respectfully traversed. Initially, note that claims 1, 2, 4, 5, 10 and 15 do not utilize the term "selective oxidation", or any form of the term "selective oxidation"; accordingly, basis for rejection of these claims, and claims dependent thereon, due to the lack of a written description of the claim limitation "selective oxidation" in the application as filed, is not understood.

In any event, and as discussed previously, it is respectfully submitted that Applicants' disclosure, including their Specification, as originally filed, clearly discloses oxidizing substantially only a portion at the upper end of the trench and substantially not at other parts of the trench. It is respectfully submitted that this description clearly shows to one of ordinary skill in the art that Applicants considered as part of their invention a selective oxidation of the upper end portion of the trench. It is respectfully submitted that this is all that is required under the first paragraph of 35 USC 112, under the present circumstances. It is respectfully submitted that Applicants need not utilize the term "selective oxidation" in their Specification in order to satisfy requirements of 35 USC 112, first paragraph, where their Specification establishes that the selective oxidation of the upper end portion of the trench was part of their invention as originally filed.

In view of the foregoing, reconsideration and withdrawal of the claim rejection under the first paragraph of 35 USC 112, as set forth in Item 3 on page 3 of the Office Action mailed July 30, 2002, are respectfully requested.

Applicants respectfully traverse the rejection of claims 1-6 under the second paragraph of 35 USC 112, as being indefinite, as set forth in Item 4 on page 3 of the Office Action mailed July 30, 2002. Contrary to the conclusion by the Examiner, it is respectfully submitted that Applicants' disclosure and claims are clearly definite in connection with the oxidation of <u>only</u> a portion of the semiconductor substrate, <u>at the upper end portion of the trench, and not substantially at other portions of the substrate lining the trench</u>. In this regard, attention is again respectfully directed to the description of aspects of the present invention, as set forth on pages 14 and 15 of Applicants' Specification. In particular, note the description that oxidation proceeds from near the trench upper end 12 <u>and the inside of the trench is hardly oxidized</u>. That is, a longer time is necessary for the oxidation seeds to diffuse inside the buried insulating film 9 before reaching the silicon substrate 1 than when the silicon substrate is directly oxidized; and, therefore, oxidation hardly proceeds substantially within a short period of several minutes near the bottom of the trench. In other words, the buried insulating film 9 in essence acts somewhat as a mask such that oxidation hardly proceeds near the bottom of the trench. Clearly, this describes aspects of the present invention as in the present claims, and the present claims are clearly definite, in specifying that oxidation substantially occurs only (in other words, selective oxidation) at the upper end portion of the trench.

The contention by the Examiner that the whole wafer is subjected to oxidation, just a portion or any portion, is noted. However, note that the present claims do not

recite subjecting to oxidation, but rather recite the action of oxidation, and recite the specific parts of the substrate which are oxidized. This is entirely consistent with, for example, having a mask portion on the substrate, wherein selective portions of the substrate are oxidized. Clearly, the present claims define the metes and bounds of the present process, sufficiently to satisfy the requirements of the second paragraph of 35 USC 112. See In re Moore, 169 USPQ 236 (CCPA 1971).

Objection to claim 40, in Item 5 on page 4 of the Office Action mailed July 30, 2002, is moot in view of present cancellation of claim 40.

Applicants respectfully submit that all of the claims now presented for consideration by the Examiner patentably distinguish over the teachings of the references applied by the Examiner in rejecting the claims in the Office Action mailed July 30, 2002, that is, the teachings of U.S. Patent No. 5,679,599 to Mehta, Japanese Patent Document No. 1-107554 (Kojiro), and the article by Lee, et al., "An Optimized Densification Of The Filled Oxide For Quarter Micron Shallow Trench Isolation (STI)", from the 1996 Symposium on VLSI Technology Digest of Technical Papers, pages 158 and 159, under the provisions of 35 USC 103.

Initially, Applicants note contentions by the Examiner in Item 11 on page 20 of the Office Action mailed July 30, 2002. Previous to this Office Action mailed July 30, 2002, the Examiner had not provided evidence establishing a date of publication of the Lee, et al. article, and Applicants were within their rights in contending a publication date at the end of 1996, since the article was published in a digest with "1996" in its title and no date of publication was offered by the Examiner. On the other hand, the Examiner has now provided an Abstract, with the Office Action

mailed July 30, 2002. For present purposes, the Lee, et al. article is being treated as prior art in connection with the above-identified application.

It is respectfully submitted that the references as applied by the Examiner would have neither taught nor would have suggested such a method of fabricating a semiconductor device as in the present claims, including, inter alia, after burying the buried insulating film, wherein the insulating film is also formed on the oxidation prevention film, removing the insulating film on the oxidation prevention film; and, thereafter, oxidizing only a portion of the semiconductor substrate, at the upper end portion of the trench, and not substantially at other portions of the semiconductor substrate lining the trench, so as to provide a curvature of the upper end portion of the trench (note, for example, claim 1); with the oxidation prevention film being eliminated, and, thereafter, forming a gate oxide film. Note claim 1. See also claims 2, 4, 5 (claim 5 defining a method of fabricating a semiconductor substrate) and 10.

Moreover, it is respectfully submitted that these applied references would have neither disclosed nor would have suggested such a method of fabricating a semiconductor device, including forming an insulating film inside oxidized trench regions so as to completely fill them, thereby forming completely filled trench regions and forming the insulating film on an oxidation prevention film; then removing the insulating film formed on the oxidation prevention film and thereafter performing a second oxidation to selectively oxidize only an opening side of the completely filled trench regions in the substrate (see claim 9); and after performing this second oxidation to selectively oxidize only an opening side of the completely filled trench regions in the substrate, removing the oxidation prevention film, and forming a gate oxide film. See claim 9.

In addition, it is respectfully submitted that these references would have neither taught nor would have suggested such a method of fabricating a semiconductor device as in the present claims, including oxidizing a trench portion, exposed in a trench formed in a semiconductor substrate, so as to provide the upper end portion thereof with a curvature; and after burying a buried insulating film into the trench so oxidized, with the insulating film also being formed on an oxidation prevention film on the semiconductor substrate, removing the insulating film formed on the oxidation preventive film, and after this removal of the insulating film from the oxidization prevention film performing thermal oxidation of the substrate only at the upper end portion of the trench, to increase the curvature of the upper end portion of the trench as compared with a curvature provided when oxidizing the trench portion (see claim 15), with the oxidation prevention film being removed. See claim 15. Note also claims 41, 43, 46 and 47. See also claim 5.

Moreover, it is respectfully submitted that the teachings of the applied prior art would have neither disclosed nor would have suggested such a method of fabricating a semiconductor device as in the present claims, including burying a buried insulating film into oxidized trenches in a substrate, the insulating film also being formed on an oxidation prevention film on the substrate; selectively oxidizing the semiconductor substrate after the insulating film on the oxidation prevention film is removed, with the upper end portions not covered by the oxidation prevention film being oxidized (see claim 45; see also claim 4); and removing the oxidation prevention film. See claim 45. See also claim 4.

Furthermore, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested the other

aspects of the present invention as in the present claims, having the processing steps discussed previously, and also including formation of a shallow trench and then forming trenches having a predetermined depth to the shallow trenches (note, for example, claims 2, 5 and 43); and/or wherein the step of eliminating the oxidation prevention film is performed after selective oxidation of the semiconductor substrate at the upper end portion (note, for example, claims 42, 44 and 48); and/or material, and techniques of formation, of the buried insulating film as in claims 18-38; and/or wherein an angle between the circuit formation surface of a substrate and a side surface of the semiconductor substrate forming the trench is within a range as in claim 13; and/or wherein the oxidizing the trench portion to provide the upper end portion of the trench with a curvature is a thermal oxidization (see claim 17, for example).

The invention as presently claimed in the above-identified application is directed to a method of manufacturing a semiconductor substrate, or semiconductor device, having a trench isolation structure. A process forming a so-called "trench isolation structure", which forms trenches extending into the substrate from the substrate surface and then selectively oxidizes the trenches to form a thermal oxide film, has been employed to form insulation/isolation structure of semiconductor devices, as described in the paragraph bridging pages 1 and 2 of Applicants' specification.

In the trench isolation structure, end points (corner points) essentially exist near the trench upper end portion of the semiconductor substrate. Stress concentration fields (both mechanical stress and electrical stress) are formed near the end points. Because such stress concentration fields are formed, the shape of

the substrate, particularly near the trench upper end portion, is oxidized in some cases into a pointed shape having an acute angle, as shown by the structure represented by reference character 4 in Fig. 1C of Applicants' disclosure. If such an acute angle portion 4 remains on the semiconductor surface, however, concentration of electric field occurs at this portion during the circuit operation and deteriorates the breakdown voltage characteristics of transistors, capacitors, etc., formed utilizing such substrate. Moreover, mechanical stress fields, which are disadvantageous, are also formed. See the paragraph bridging pages 3 and 4 of Applicants' specification.

Against this background, Applicants provide a process wherein trench isolation can be utilized, without causing deterioration of breakdown voltage characteristics of transistors and capacitors utilizing the substrate with the trench isolation structure, while providing semiconductor devices having a high reliability. Moreover, Applicants fabricate such structure utilizing a relatively simple technique.

Applicants have found that the desired structure can be achieved by preventing a substrate shape in the proximity of the upper end portion of the device isolation trench from becoming an acute angle; and, by the present invention, provide simple techniques for preventing such acute angle. Specifically, according to the present invention, Applicants provide procedures which can easily and effectively provide a curvature (increased curvature) only of an upper end portion of the trench, by selectively oxidizing only the upper end portion, so as to prevent the aforementioned acute angle. For example, and specifically, according to the present invention, after burying the buried insulating film, this insulating film also being formed on an oxidation prevention film on the semiconductor substrate, this

insulating film on the oxidation prevention film is removed and then the upper end portion of the trench is oxidized while the lower portion of the trench is substantially not oxidized, whereby the semiconductor substrate can be oxidized (selectively) at only the upper end portion of the trench, and not substantially at other portions of the semiconductor substrate lining the trench. Removal of the insulating film from the oxidation prevention film, prior to oxidation (selectively), can, for example, uncover upper end portions of the trench, facilitating oxidation of the upper end portions. Moreover, more generally, after burying the buried insulating film and removal of this insulating film from the oxidation prevention film on the substrate, an upper end portion of the trench can be provided with the curvature (increased curvature). This prevention of the acute angle can be achieved, for example, by thermal oxidation of substantially only the upper end portion of the trench; e.g., by forming bird's beaks at the upper end portion of the trench.

As is clear according to the specification of the present application, since the buried insulating film 9 (see, e.g., Fig. 2(g)) has already been formed inside the trench of the silicon substrate 1, especially wherein the insulating film 9 has been removed from on the oxidation prevention film (e.g., at the upper end portion of the trench) oxidation proceeds from near the trench upper end portion 12, and the inside of the trench is hardly oxidized. That is, a longer time is necessary for oxidation seeds to diffuse inside the buried insulating film 9 before reaching the silicon substrate 1 at lower portions of the trench, than when the silicon substrate is directly oxidized. Therefore, oxidation hardly proceeds substantially near the bottom of the trench. On the other hand, a weak boundary layer of the coupling portion deposited by chemical vapor deposition or sputtering to the trench sidewalls and the upper

surface of the trench exists at the trench upper end portion 12, and oxidation seeds can diffuse at a relatively high rate along this weak boundary layer, and especially where the insulating film has been removed from on the oxidation prevention film. As a result, oxidation seeds are supplied to the trench upper end portion 12 within a short time, so that only the portions in the proximity of the trench upper end portion 12 are oxidized preferentially and the formation of the radius of curvature of the trench upper end portion 12 is promoted. Note, for example, the paragraph bridging pages 14 and 15 of Applicants' specification.

It is emphasized that according to the present invention, Applicants have recognized that curvature formation including, for example, at the upper end portion of the trench, is important to reduce concentration of both mechanical and electrical stress fields, in order to provide a reliable device with shallow trench insulation. Having recognized this, Applicants provide simple techniques for increasing curvature (providing roundness) at the top corners of the trench; and, according to various aspects of the present invention, provide such increased curvature by, e.g., additional oxidation <u>after</u> filling the trench and <u>after</u> removal of filler material on the oxidation prevention film and <u>prior to</u> removal of the oxidation prevention film. Only a small amount of oxidation is utilized to provide the roundness at the upper corners of the trench (for example, the oxidation is performed for only a short time; and, according to the invention as presently claimed, the filler material (of, for example, chemical vapor deposited oxide) is removed prior to performing the additional oxidation to increase curvature), with the oxidation prevention film being removed <u>after</u> the additional oxidation.

Thus, according to the present invention, simple techniques are provided to

achieve increased radius of curvature at top corners of the trench, so as to reduce concentration of both mechanical and electrical stress fields, so as to provide reliable semiconductor devices.

The article by Lee, et al. reports on a comparison of densification methods using H_2O and N_2 ambient annealing of filled chemical vapor deposited (CVD) oxide for quarter micron shallow trench isolation (STI). This article discloses that a densification in an oxidizing ambient causes an unwanted side wall oxidation, which in turn exerts an extreme stress toward the active Si area of the devices, and that if this stress surpasses the yield stress of the silicon it forms crystallographic defects such as dislocations which increase the leakage current of the STI. The article discloses experimentation wherein at first field and active regions are defined by photolithography and etch steps. Trench sidewall oxide was grown, and CVD oxide was deposited to fill the trenches; and two densification processes were performed separately, one in H_2O ambient and the other in N_2 ambient. Chemical mechanical polishing was then applied to planarize the CVD oxide until SiN was exposed, the SiN layer was subsequently removed in phosphoric acid, and channel stop implantation was carried out. The, the pad oxide was removed in a diluted HF solution. In the results shown in this article, N^+/P junction leakage currents occurred in H_2O densification, the leakage current increasing as the isolation size becomes smaller. On the other hand, no increase in the leakage current occurred upon densification in the N_2 ambient.

This article is concerned with <u>densification</u>, and discloses advantages achieved utilizing <u>an inert N_2 ambient</u>. <u>Relatively long annealing is performed for densification</u>; and it is respectfully submitted that this article would have neither

taught nor would have suggested the selective oxidation, or oxidation substantially only at the upper end portions of the trench, and advantages achieved thereby, as described in the foregoing.

Moreover, note that the chemical mechanical polishing in Lee, et al. was applied after the densification process. This disclosure in Lee, et al. would have taught away from the presently claimed process, including wherein the insulating film on the oxidation prevention film is removed before oxidizing only a portion of the semiconductor substrate, at the upper end portion of the trench.

The contention by the Examiner that Lee, et al. discloses providing a curvature of the upper end portion of the trench, by selective oxidation, set forth in Item 6 of the Office Action mailed July 30, 2002, is respectfully traversed. The Examiner is respectfully requested to set forth the specific portion of Lee, et al., disclosing such providing of a curvature of the upper end portion by selective oxidation (or oxidation of substantially only the upper end portion of the trench). As discussed previously, particularly in view of the relatively long oxidation used in Lee, et al., it is respectfully submitted that this reference would have neither disclosed nor would have suggested, and in fact would have taught away from, the oxidizing of only a portion of the semiconductor substrate, at the upper end portion, or the selective oxidation, as in the present claims.

In this regard, Applicants respectfully traverse the conclusion by the Examiner in the paragraph bridging page 5 and 6 of the Office Action mailed July 30, 2002, that Lee, et al. discloses performing a second oxidation "to selectively oxidize only an opening side of the completely filled trench regions in the substrate".

The contention by the Examiner in connection with claim 13, in the last

paragraph on page 7 of the Office Action mailed July 30, 2002, is noted. The Examiner is respectfully challenged to point out the specific portion of Lee, et al.. describing formation of the angle as in the present invention. In this regard, the Examiner is respectfully reminded that rejections must be based on evidence or reasoning, and not mere allegations. See In re McKellin, 188 USPQ 428 (CCPA 1976).

In connection with the subject matter of claims 14, 39 and 40, it is respectfully submitted that the additional teachings of Mehta would not have rectified the deficiencies of Lee, et al., such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art. Mehta discloses a combination of (1) trench isolation and (2) local oxidation of silicon, as isolation processes. See column 1, lines 8-10. The process described in Mehta includes forming a first insulation region and a second insulation region; etching a trench in the first insulation region, the trench extending into the semiconductor substrate to a depth below the surface of the semiconductor substrate; filling the first insulation region with an isolation material and removing a portion of the isolation material such that the trench isolation material fills the trench and has a surface level with the surface of a substrate; and thermally growing a field oxide in the first and second insulation regions. Note the paragraph bridging columns 3 and 4 of this patent. See also column 4, lines 47-51; column 5, lines 37-42 and 64-67; and column 6, lines 4-9 and 19-23.

Initially, it is respectfully submitted that Lee, et al. discloses, as a comparative method, densification in a water atmosphere. This article specifically discloses annealing in the N_2 ambient to densify the CVD oxide efficiently without causing any

abnormalities in the isolation and the MOS device characteristics. Taking the teachings of this article as a whole, it is respectfully submitted that one of ordinary skill in the art would not have looked to the teachings of Mehta, which provides both trench isolation and conventional LOCOS isolation, forming a field oxide.

In addition, it is emphasized that Mehta discloses a further oxidation in order to provide the thick field oxide region 240, and field oxidized trench region 242. Note Fig. 18 and the corresponding description in column 6, lines 19-23 of Mehta. It is respectfully submitted that even assuming, arguendo, the teachings of Mehta were properly combinable with the teachings of Lee, et al., such combined teachings would have neither disclosed nor would have suggested the selective oxidation, or the oxidizing of only a portion of a substrate, at the upper end portions of the trenches and not substantially at other portions of the semiconductor substrate lining the trenches, as in the present claims. In this regard, attention is again directed to, for example, the description on pages 14 and 15 of Applicants' Specification, describing that by, for example, limiting the oxidation, after removing the insulating film from the oxidation prevention film, to a relatively short time period, the upper end portions of the trenches can be oxidized while not substantially oxidizing other portions of the substrate lining the trenches. In view of the relatively long oxidation period for forming the field oxide in Mehta, it is respectfully submitted that the teachings of Mehta, either alone or in combination with the teachings of Lee, et al., would have taught away from the present invention including the selective oxidation and advantages thereof.

It is respectfully submitted that the combined teachings of Lee, et al. and Kojiro would have neither taught nor would have suggested the subject matter of

claims 2, 3, and 21-23, of the present claims. Lee, et al. has been previously discussed.

Kojiro discloses a technique of forming a trench for isolation, which has small leakage current, by forming a taper in the opening of the trench. In the described process of Kojiro, with an oxide film 2 as a mask a silicon substrate 1 is isotropically plasma-etched, a recess of circular-arc-shaped section is formed; and, further, the recess is anisotropically etched with the film 2 as a mask, a trench 3 of desired depth is formed, and the film 2 of the mask is then removed. The formed trench has a taper 3a in the opening.

Even assuming, arguendo, that the teachings of Lee, et al. and of Kojiro were properly combinable, such combined teachings would have neither disclosed nor would have suggested the presently claimed process, including, inter alia, burying the buried insulating film into the trenches with insulating film being formed on the oxidation prevention film; removing the insulating film formed on the oxidation prevention film; and oxidizing only a portion of the substrate extending from the corners (upper end portions), and not substantially at other portions of the substrate lining the trenches, after removing the insulating film on the oxidation prevention film, to increase the radius of curvature of the shallow trenches, and advantages thereof as in the present invention.

While the Examiner contends that Lee, et al. discloses oxidizing only portions of the semiconductor substrate extending from the corners "so as to increase the curvature of the [trench] corners", it is respectfully submitted that Lee, et al. does not disclose oxidizing "only a portion" of the substrate, much less oxidizing only a portion "so as to increase the curvature of the [trench] corner"; and, moreover, would have

taught away from such increase in curvature in disclosing that densification in H_2O generates defects while densification in N_2 densifies efficiently without causing any abnormalities.

It is respectfully submitted that the teachings of Mehta would have neither disclosed nor would have suggested the presently claimed subject matter, as in claims 4, 24-26, 41, 42 and 45-48. Specifically, teachings of this reference would have neither disclosed nor would have suggested the oxidizing of only a portion of the substrate at the upper end portions of the trenches, and not substantially at other portions of the semiconductor substrate lining the trenches; or the selective oxidation, providing advantages as in the present invention. In this regard, it is again emphasized that the field oxidation step in Mehta is a relatively long oxidation equivalent to that utilized in a conventional LOCOS process, and forms, inter alia, field oxidized trench region 242. It is respectfully submitted that this disclosure in Mehta would have neither taught nor would have suggested, and in fact would have taught away from, the selective oxidation, or oxidizing only a portion of the substrate at the upper end portion of the trenches and not substantially at other portions of the substrate lining the trenches, and advantages thereof as in the present claims.

In addition, it is respectfully submitted that Mehta would not have disclosed nor would have suggested the step for forming the curvature at the corner of the trench by thermal oxidization after the formation of the trench, and steps for increasing curvature by further additional oxidation after the trench is buried. Since Mehta discloses formation of a spacer on the substrate, and since any thermal oxidation is carried out with the spacer, it is respectfully submitted that oxidation at the upper portion of the trench is suppressed according to Mehta, and an oxidation

film is formed substantially <u>inside</u> the trench. Accordingly, it is respectfully submitted that the curvature at the upper end of the trench is <u>not</u> substantially formed by, e.g., original thermal oxidation, and that the curvature, if any, is formed at the upper portion by oxidation after the trench is buried. Thus, it is respectfully submitted that Mehta would have neither taught nor would have suggested the present invention, including, <u>inter alia</u>, the selective oxidation or the oxidizing to provide the upper end portion of the trench with a radius of curvature (note, for example, claims 41, 45, 46 and 47, and claims dependent thereon).

It is respectfully submitted that the additional teachings of Kojiro would not have rectified the deficiencies of Mehta, such that the combined teachings of these references would have rendered obvious the subject matter of claims 5, 6, 27-29, 43 and 44. The teachings of each of Mehta and of Kojiro have previously been discussed. Even assuming, <u>arguendo</u>, that the teachings of Mehta and of Kojiro were properly combinable, such combined teachings would have neither disclosed nor would have suggested the presently claimed subject matter, including the oxidation of only a portion of the substrate, at the upper end portion of the trench, and not substantially at other portions of the substrate lining the trench, or the selective oxidation of the upper end portion of the trench, and advantages thereof as discussed in the foregoing.

Moreover, the combined teachings of the applied references would have neither disclosed nor would have suggested the other aspects of the present invention as discussed previously, and advantages thereof.

The contention by the Examiner that the second oxidation of the applied references would also result in the additional oxidation of the trench corner is noted.

However, note that the present claims recite <u>selective</u> oxidation, or <u>oxidation substantially only in the upper end portions</u>; it is respectfully submitted that the teachings of the applied references do not disclose, nor would have suggested, and as discussed previously would have taught away from, the selective oxidation of the upper trench corners as in the present invention.

Contentions by the Examiner in the fifth paragraph of Item 12, on page 21 of the Office Action mailed July 30, 2002, with respect to Mehta, are noted. As has been shown in the foregoing, Applicants' originally filed Specification <u>clearly</u> describes oxidation of only a portion of the semiconductor substrate at the upper trench portion of the trench and not substantially at other portions of the semiconductor substrate lining the trench. Clearly the Examiner errs in his conclusion as to new matter.

In any event, it is respectfully submitted that in a consideration of the prior art, the Examiner must consider the <u>present claims</u>, including <u>all</u> limitations. The Examiner has failed to establish obviousness, with respect to Mehta, of oxidizing only a portion of the semiconductor substrate, at the upper end portion of the trench, and not substantially at other portions of the semiconductor substrate lining the trench; and/or the selective oxidation, of the present claims.

In view of the foregoing comments and amendments, reconsideration and withdrawal of the finality of the Office Action mailed July 30, 2002, and, correspondingly, entry of the present amendments, and reconsideration and allowance of all claims remaining in the application, are respectfully requested.

In any event, entry of the present amendments, and reconsideration and allowance of all claims remaining in the application, are respectfully requested.

Attached hereto is a marked-up version of the changes made to the claims by the current Amendment After Final Rejection. The changes are shown on the attached pages, the first page of which is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

To the extent necessary, Applicants petition for an extension of time under 37 CFR §1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 01-2135 (500.36904X00) and please credit any excess fees to such deposit account.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

Please amend the claims as indicated below:

1. (Four Times Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming a trench having a desired depth at a predetermined position of the circuit formation surface of said semiconductor substrate, said trench having an upper end portion adjacent the circuit formation surface of the semiconductor substrate;

(c) oxidizing a trench portion formed in said semiconductor substrate, exposed in said trench;

(d) burying a buried insulating film into said trench so oxidized, said insulating film also being formed on the oxidation prevention film;

(e) after burying said buried insulating film, removing said insulating film on the oxidation prevention film;

(f) after said removing, oxidizing only a portion of said upper end portion of the trench, and not substantially at other portions of the semiconductor substrate lining the trench, so as to provide a curvature of the upper end portion of the trench;

[(f) removing said buried insulating film formed on said oxidation prevention film;]

(g) eliminating said oxidation prevention film formed on said semiconductor substrate; and

(h) after said eliminating, forming a gate oxide film.

2. (Four Times Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming shallow trenches having a radius of curvature at corners in a desired position of the circuit formation surface of said semiconductor substrate;

(c) forming trenches having a predetermined depth to said shallow trenches having a radius of curvature so formed;

(d) oxidizing trench portions formed in said semiconductor substrate, exposed in said trenches;

(e) burying a buried insulating film into said trenches so oxidized<u>, with said insulating film being formed on said oxidation prevention film</u>;

<u>(f) removing said insulating film formed on said oxidation prevention film;</u>

[(f)] <u>(g)</u> oxidizing only a portion of the semiconductor substrate extending from said corners, and not substantially at other portions of the semiconductor substrate lining the trenches, after [burying] said <u>removing</u> [buried insulating film], so as to increase the radius of curvature of the shallow trenches;

[(g) removing said buried insulating film formed on said oxidation prevention film;]

(h) eliminating said oxidation prevention film formed on said semiconductor substrate; and

(i) after said eliminating, forming a gate oxide film.

4. (Four Times Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming trenches having a predetermined depth at desired positions of the circuit formation surface of said semiconductor substrate, said trenches having upper end portions not covered by said oxidation prevention film;

(c) oxidizing trench portions formed in said semiconductor substrate, exposed in said trenches;

(d) burying a buried insulating film into said trenches so oxidized, said insulating film also being formed on said oxidation prevention film;

(e) removing said insulating film on said oxidation prevention film;

(f) after said removing, oxidizing only a portion of said semiconductor substrate at said upper end portions of said trenches, and not substantially at other portions of the semiconductor substrate lining the trenches, [after said buried insulating film formed on said oxidation prevention film is removed,] said upper end portions not covered by said oxidation prevention film being oxidized;

(g) removing said oxidation prevention film formed on the circuit formation surface of said semiconductor substrate; and

~~(h) after said oxidizing said semiconductor substrate, forming a gate oxide~~ film.

5. (Four Times Amended) A method of fabricating [as] a semiconductor substrate comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming shallow trenches having a radius of curvature at corners in desired positions of the circuit formation surface of said semiconductor substrate;

(c) forming trenches having a predetermined depth in said shallow trenches having a radius of curvature;

(d) oxidizing trench portions formed in said semiconductor substrate, exposed in said trenches;

(e) burying a buried [insulation] insulating film into said trenches so oxidized, said insulating film also being formed on said oxidation prevention film;

(f) removing said [buried] insulating film formed on said oxidation prevention film;

(g) after said removing, oxidizing only a portion of said semiconductor substrate extending from said corners, and not substantially at other portions of the semiconductor substrate lining the trenches, [after said buried insulating film formed on said oxidation prevention film is removed,] so as to increase the radius of curvature of the shallow trenches at said corners;

(h) removing said oxidation prevention film formed on the circuit formation surface of said semiconductor substrate; and

~~(i) after said oxidizing said semiconductor substrate, forming a gate oxide~~ film.

9. (Four Times Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate,

(b) forming trench regions in said substrate from said circuit formation surface thereof,

(c) performing a first oxidation to form an oxide film on said trench regions formed in step (b), and

(d) forming an insulating film inside said oxidized trench regions so as to completely fill them, thereby forming completely filled trench regions, and forming the insulating film on the oxidation prevention film,

characterized by further steps of:

(e) removing said insulating film formed on the oxidation prevention film;

(f)[(e)] after said removing, performing a second oxidation to selectively oxidize only an opening side of said completely filled trench regions in said substrate; and

(g)[(f)] after performing the second oxidation, removing said oxidation prevention film, and forming a gate oxide film.

10. (Thrice Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming a trench having a desired depth at a predetermined position of the circuit formation surface of said semiconductor substrate, the trench having an upper end portion thereof extending to the circuit formation surface of the

semiconductor substrate;

(c) oxidizing a trench portion formed in said semiconductor substrate, exposed in said trench;

(d) burying a buried insulating film into said trench so oxidized, the insulating film also being formed on the oxidation prevention film;

(e) removing the insulating film formed on the oxidation prevention film;

(f)[(e)] after [burying] said [buried insulating film] removing, oxidizing only a portion of the semiconductor substrate, at the upper end portion of said trench and not substantially at other portions of the semiconductor substrate lining the trench, to provide the upper end portion with a curvature;

[(f) removing said buried insulating film formed on said oxidation prevention film;] and

(g) removing said oxidation prevention film formed on the circuit formation surface of said semiconductor substrate.

15. (Thrice Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming a trench having a desired depth at a predetermined position of the circuit formation surface of said semiconductor substrate, the trench having an upper end portion thereof extending to the circuit formation surface of the semiconductor substrate;

(c) oxidizing a trench portion formed in said semiconductor substrate,

exposed in said trench, so as to provide the upper end portion of said trench with a curvature;

(d) burying a buried insulating film into said trench so oxidized, the insulating film also being formed on the oxidation prevention film;

(e) removing said [buried] insulating film formed on said oxidation prevention film, having said buried insulating film in said trench;

(f) after said removing, performing thermal oxidation of the semiconductor substrate only at the upper end portion of the trench, to increase the curvature of the upper end portion of the trench as compared with the curvature provided in step (c); and

(g)[(f)] removing said oxidation prevention film formed on the circuit formation surface of said circuit substrate.

39. (Amended) A method of fabricating a semiconductor device according to claim 15, wherein[, after the step (e) of removing said buried insulating film and before] the step (f) of removing said oxidation prevention film is performed after said performing thermal oxidation. [, the further step of performing thermal oxidation of the semiconductor substrate only at the upper end portion of the trench, to increase the curvature of the upper end portion of the trench as compared with the curvature provided in step (c).]

41. (Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a

semiconductor substrate;

(b) forming a trench having a desired depth at a predetermined position of the circuit formation surface of said semiconductor substrate, said trench having an upper end portion adjacent the circuit formation surface of the semiconductor substrate;

(c) oxidizing a trench portion formed in said semiconductor substrate, exposed in said trench, forming a curvature of said upper end portion of said trench;

(d) burying a buried insulating film into said trench so oxidized, the insulating film also being formed on the oxidation prevention film;

(e) removing the insulating film formed on the oxidation prevention film;

(f)[(e)] after [burying] said [buried insulating film] removing, selectively oxidizing said semiconductor substrate at said upper end portion so as to provide an increased curvature of the upper end portion of the trench as compared with the curvature formed in step (c);

[(f) removing said buried insulating film formed on said oxidation prevention film;]

(g) eliminating said oxidation prevention film formed on said semiconductor substrate; and

(h) after said eliminating, forming a gate oxide film.

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42. (Amended) A method of fabricating a semiconductor device according to claim 41, wherein [the step (f) of removing the buried insulating film is performed before the step (e) of selectively oxidizing said semiconductor substrate at said upper end portion, and] the step (g) of eliminating said oxidation prevention film is

performed after the step [(e)] (f) of selectively oxidizing said semiconductor substrate at said upper end portion.

43. (Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming shallow trenches having a radius of curvature at corners in a desired position of the circuit formation surface of said semiconductor substrate;

(c) forming trenches having a predetermined depth to said shallow trenches having a radius of curvature so formed;

(d) oxidizing trench portions formed in said semiconductor substrate, exposed in said trenches;

(e) burying a buried insulating film into said trenches so oxidized, said insulating film also being formed on the oxidation prevention film;

(f) removing said insulating film formed on the oxidation prevention film;

(g)[(f)] selectively oxidizing the semiconductor substrate after [burying] said [buried insulating film] removing, so as to increase the radius of curvature at the corners of the shallow trenches as compared to the radius of curvature formed in step (b);

[(g) removing said buried insulating film formed on said oxidation prevention film;]

(h) eliminating said oxidation prevention film formed on said semiconductor substrate; and

(i) after said eliminating, forming a gate oxide film.

44. (Amended) A method of fabricating a semiconductor device according to claim 43, wherein [the step (g) of removing said buried insulating film is performed prior to the step (f) of selectively oxidizing, and] the step (h) of eliminating said oxidation prevention film is performed after the step [(f)] (g) of selectively oxidizing.

45. (Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming trenches having a predetermined depth at desired positions of the circuit formation surface of said semiconductor substrate, said trenches having upper end portions not covered by said oxidation prevention film;

(c) oxidizing trench portions formed in said semiconductor substrate, exposed in said trenches, so as to provide a curvature at said upper end portions of the trenches;

(d) burying a buried insulating film into said trenches so oxidized, the insulating film also being formed on the oxidation prevention film;

(f) selectively oxidizing said semiconductor substrate after said [buried] insulating film formed on said oxidation prevention film is removed, said upper end portions not covered by said oxidation prevention film being oxidized;

(g) removing said oxidation prevention film formed on the circuit formation surface of said semiconductor substrate; and

(h) after said oxidizing said semiconductor substrate, forming a gate oxide film.

46. (Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate,

(b) forming trench regions in said substrate from said circuit formation surface thereof,

(c) performing a first oxidation to form an oxide film on said trench regions formed in step (b), so as to provide a curvature at an opening side of the trench regions, and

(d) forming an insulating film inside said oxidized trench regions so as to completely fill them, the insulating film also being formed on the oxidation prevention film

characterized by further steps of:

(e) removing said insulating film formed on the oxidation prevention film;

(f)[(e)] after said removing, performing a selective second oxidation to selectively oxidize the opening side of said completely filled trench regions in said substrate, so as to provide an increased curvature at the opening side as compared to said curvature provided in step (c); and

(g)[(f)] after performing the second oxidation, removing said oxidation prevention film and forming a gate oxide film.

47. (Amended) A method of fabricating a semiconductor device comprising the steps of:

(a) forming an oxidation prevention film on a circuit formation surface of a semiconductor substrate;

(b) forming a trench having a desired depth at a predetermined position of the circuit formation surface of said semiconductor substrate, the trench having an upper end portion thereof extending to the circuit formation surface of the semiconductor substrate;

(c) oxidizing a trench portion formed in said semiconductor substrate, exposed in said trench, thereby providing the upper end portion of the trench with a radius of curvature;

(d) burying a buried insulating film into said trench so oxidized, said insulating film also being formed on the oxidation prevention film;

(e) removing said insulating film formed on the oxidation prevention film;

(f)[(e)] after [burying] said [buried insulating film] removing, providing the upper end portion of said trench with an increased radius of curvature, as compared with the radius of curvature provided in step (c), by selectively oxidizing the upper end portion of the trench;

[(f) removing said buried insulating film formed on said oxidation prevention film;] and

(g) removing said oxidation prevention film formed on the circuit formation surface of said semiconductor substrate.

48. (Amended) A method of fabricating a semiconductor device according

to claim 47, wherein the [step (f) of removing the buried insulating film formed on said oxidation prevention film is performed prior to the step (e) of providing the upper end portion of the trench with an increased radius of curvature, and the] step (g) of removing the oxidation prevention film is performed after the step [(e)] (f) of providing the upper end portion of the trench with an increased radius of the curvature.